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THE ANTHROPOMETRIC ASSESSMENT

OF

FEMALE SENIOR AND JUNIOR PROVINCIAL

FIELD HOCKEY PLAYERS

BY

© GAIL MARIE R. AMORT

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled, "The Anthropometric Assessment of Female Senior and Junior Provincial Field Hockey Players," submitted by Gail Marie R. Amort in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The purpose of this study was to show that there were anthropometric measurements characteristic of a specific position in women's field hockey - goalie, fullback, halfback and forward - and that these characteristics were present at a senior as well as junior category.

The sample consisted of one hundred and six female senior and junior provincial field hockey players from five Canadian provinces. Of these one hundred and six subjects, fifty-five players were from the junior provincial teams while the remaining fifty-one players were from the senior provincial teams.

A total of twenty-eight individual anthropometric measurements were taken on each subject with another ten comparative indices being calculated.

Two way analysis of variance was employed to examine the data as each anthropometric measurement was analysed with respect to two age levels and four field hockey positions in the sport of field hockey.

The study concluded that the majority of field hockey players had a high mesomorphic component with varying degrees of ectomorphy and endomorphy.

The relationship between the anthropometric data in junior and senior levels of field hockey was significant at the .05 level for knee circumference and for bicristal breadth.

There were no significant variations among the various positions in field hockey when related to the anthropometric data.

The interaction of age-by-position was significant at the .05 level for tricep skinfold and crural index.

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CHAPTER I

INTRODUCTION

By merely observing the various athletes in their selective sport, one is able to focus upon the idea that each sporting discipline has its own distinct characteristic body physique. Many researchers such as Hirata (27), Malina (38), Sheldon (51), Carter (8, 9, 10) and Alexander (1) have accepted and proven this idea anthropometrically and somatotypically so that it is now becoming universal. Not only does this fact exist between various sports such as football (4) and track and field, but also among positions within a sport. Malina (37) compared the physique of a linesman to that of a halfback's while Sheldon (51) compared the physique of a distance runner to that of a shot putter's. Many questions are still left unanswered. Are these structural characteristics a positive result due to the strenuous training to which the athlete subjects himself and due to the demands that he must meet within the various levels of ability to be able to compete? Is it an inherent variable of that individual? Would an athlete in a chosen field have as much or more success in a totally alien sport after training programmes of similar intensity? The answers to these questions are still to be researched.

In the past, most of the studies on physical characteristics of athletes in sports have been reported using males of Olympic and European status in individual sports. There is a lack of information concerning the physique of Canadian females in sports, especially team sports. Criteria concerning the physical characteristics required to excel in a particular sport or in a position in a sport would provide an efficient aid in objectively assessing the capabilities and potential of

an individual in a selected sport or position within a sport. This would remove some of the subjectivity that exists in the selection of participants in a sport and might provide a possible criteria on which the selection could be based. The subjective element would thus be used more effectively in the judging of ill-defined variables such as enthusiasm and temperament essential in the successful athlete.

JUSTIFICATION OF THE PROBLEM

There is evidence in Morris and Underwood's article (40) to suggest that certain anthropometrical measurements tended to define the four positions in women's field hockey - goalie, fullback, halfback and forward. There was, however, no evidence to verify whether these characteristics exist at various age levels. Thus, this thesis was designed to establish that specific anthropometric measurements did in fact exist in the four positions in field hockey - goalie, fullback, halfback and forward - and determined whether these characteristics were present in the junior and senior level.

NULL HYPOTHESIS

For each anthropometric measurement, the following null hypothesis was tested at the .05 level of significance: there is no difference in the anthropometric measurements between junior and senior age levels and four field hockey positions.

DELIMITATIONS

1. The study involved four women's junior provincial field hockey teams from British Columbia, Alberta, Manitoba and Ontario as well as four women's senior provincial field hockey teams from British Columbia, Alberta, Saskatchewan and Manitoba.
2. The junior provincial field hockey teams consisted of 55 players

under the age of nineteen as of January 1st of that playing year. They ranged in age from 16 to 19 years.

3. The senior provincial teams consisted of 51 players of any age. They ranged in age from 17 to 33 years.
4. Measuring of all junior team members occured within a four-day period from August 1st to August 4th, 1975, in Winnipeg, Manitoba, during the Junior Women's National Field Hockey Tournament.
5. Measuring of all senior team members occured within a five-day period from August 9th to August 13th, 1975, in Regina, Saskatchewan, during the Western Canada Games.

LIMITATIONS

1. The growth and development of an individual is dependent on intrinsic genetic factors that are uncontrollable variables.
2. The extrinsic environmental factors are uncontrollable by the investigator.
3. Human source of error is an area of relative limitation.

DEFINITION OF TERMS

1. Anatomical position is the position assumed when the body is standing erect with the eye focused in a horizontal direction; the arms are by the sides with the palms of the hands facing forward; the lower limbs parallel and the toes point forward.
2. Anthropometric measurements are those measurements which define the human dimensions characteristic of the human physique.
3. Bicristal breadth is the distance from the most lateral point on the iliac crest to a similar location on the opposite iliac crest.
4. Biacromial breadth is the distance from the tip of the acromion on the scapula to the tip of the acromion on the opposite scapula.

5. Bideltoid breadth is the distance from one deltoid - midway from the acromion process to the deltoid tuberosity - to a similar point on the opposite deltoid.
6. Bitrochanteric breadth is the distance from the greater trochanter on one femur to a similar location on the opposite femur.
7. Ectomorphy is an emphasis on linearity and fragility (10) in the somatotype.
8. Endomorphy is an emphasis on adipose tissue (10) in the somatotype.
9. Mesomorphy is an emphasis on muscle, bone and connective tissue (10) in the somatotype.
10. Percent body fat is that percent of body weight that is actually adipose tissue, estimated from Brozek's formula (5).

$$\%\ \text{body fat} = 100\left(\frac{4.570}{\text{body density}}\right) - 4.142$$

11. Skinfold is the thickness of the tissue consisting of a double layer of epidermis and a layer of subcutaneous fat grasped by the Lange skinfold calipers.
12. Somatoscopy is derived from two Greek words; 'somato' meaning 'body' and 'scopy' meaning 'to examine.' Thus somatoscopy is the examination of physique and, by convention, includes the attempt to categorize the human body into specific types.
13. The Canadian Women's Field Hockey Association determines the age limits for the junior and senior provincial teams. All junior players must be under the age of nineteen as of January 1st of that playing year while the seniors can be of any age.

CHAPTER II

REVIEW OF LITERATURE

It is becoming generally accepted as common knowledge that man is a unique creature and that no two human beings are identical. Not only in physical structure does this phenomenon exist but it also holds true for temperaments or personalities (51, 52). Due to this uniqueness of individuality man finds himself in a quandry when it comes to studying the human being categorically. For generations scientists have been working towards a system in which a criteria may be established for classifying physique in order to learn more about its role in the total biological and psychological makeup of the human being. Scientists have tried to show a link between the influence of body build and temperament. (51) They have tried to show that specific physiques are prone to certain types of physical diseases, psychological disorders and athletic performances.

The ancient Greeks were among the first civilizations to classify their athletes into groups. Hippocrates, a Greek physician of 400BC, related two fundamental physical types: the phthistic habitus, a long slender structure primarily of vertical dimensions and the apoplectic habitus, a structure of short, solid, horizontal dimension. These terms were derived from the names of ailments to which each type was susceptible; the phthistic was more inclined to tuberculosis whereas the apoplectic was more prone to vascular disorders leading to apoplexy (51). Another Greek, Philostratos, around 219BC, classified Olympic athletes according to their structural similarities to animal or material objects; lion-figured, eagle-like, splinter-shaped and bear-like. (40)

In the 1800's a Frenchman by the name of Rostan put forward a new

proposal. Using the terminology previously devised by two French contemporaries, Gall and Spurzheim in 1797, Rostan enunciated that there were three types of body builds: le type digestif, le type muscularie and le type cerebral (51). This categorization is roughly analogous to the present day system.

Near the end of the 19th century, research was conducted by DiGiovanna and his pupil, Viola, in the area of clinical anthropology. Viola, through his work with anthropometric measurements, was able to differentiate a morphological index to support his claim of three morphological types: microsplanchnic, normosplanchnic, and macrosplanchnic (51). Microsplanchnic was similar to the Hippocratian term phthistic habitus while macrosplanchnic was analogous to apoplectic habitus.

Kretschmer, a German psychiatrist in the 1920's, worked with patients of a psychotic nature in an attempt to relate body types to pathological conditions. He spoke of two general types of non-organic psychosis - a circular insanity (manic depressive) and a split personality (schizophrenic). With these two specific disorders, Kretschmer was able to distinguish a general body structure for each. The manic-depressive tended to be a round-bodied, outgoing type, macrosplanchnic in nature, while the schizophrenic was more linear in body build, shy and introverted (51) similar to the microsplanchnic. A third body build, that being of an athletic nature, was also introduced by Kretschmer.

Out of these varying ideas of classification emerged a new science which implemented the use of specific anatomical structures. In 1940, the categorization of the human body according to accurate anatomical measurements took on a new method of classifying physique. This was called Somatotyping. This new approach was devised by three men;

Sheldon, Stevens and Tucker (51). Sheldon defined somatotyping as "...a quantification of the three primary components determining the morphological structure of the individual." (Sheldon, pg. 132) These three components, labelled endomorphy, mesomorphy and ectomorphy, are all present in each human to some degree. The derivatives of each component (endo, meso, ecto) play a very prominent role in the embryological development of man. Endo stems from the term endoderm, the embryonic germ layer which is responsible for the formation of the digestive visera or gut. An endomorph would thus have a predominance of soft, rounded contours throughout the various regions of the body. Meso comes from the word mesoderm, which is the embryonic germ layer which gives the body its skeletal and muscular structure. A mesomorph is a solid, rugged individual with a large skeletal and firm myological form. Ecto is a derivative of ectoderm, which is the embryonic germ layer responsible for the formation of external structures such as skin, hair, nails and the central nervous system. Ectomorphs give a linear, fragile-like appearance with little muscular support.

Each category (endomorphy, mesomorphy and ectomorphy) was based on a point scale from 1 to 7. These components are universally stated in the order given above. For example, a 7-1-1 was a predominant endomorph with very little mesomorph and ectomorph characteristics. A 1-7-1 would be a predominant mesomorph with very little endomorph and ectomorph characteristics. A 1-1-7 would be a predominant ectomorph with very little endomorph and mesomorph characteristics. These extremes can occur but are very rare. A common representative categorization may be a 4-5-3 which would be a predominant muscular individual with a reasonable amount of adipose tissue in some areas and few ectomorphic characteristics.

The sum of these three representative figures must not add up to greater than twelve to be significant.

Sheldon's method of classifying the human physique has laid the foundations for furthering investigations by countless numbers of researchers. His methods and assumptions, however, have been under various criticism, analysis and reconstruction by many authors such as Parnell, Cureton and Heath and Carter. These and others have established their own methods of categorizing the body. Cureton's approach was to use the somatotype photographic record plus measure of skinfolds, muscular strength and vital capacity. Parnell's classification is a dynamic rating that varies with nutrition and exercise. On the other hand, Sheldon's rating, according to Sheldon, is a static lifelong classification based on the individual's genotype. Heath and Carter include features of both Parnell's and Sheldon's methodology and attempt to categorize the present morphological conformation of the individual.

Numerous studies have been performed relating somatotyping and physical anthropometric measurements to the athlete. Perbix (46) at the University of Illinois in 1954 came up with findings suggesting that female physical education majors had a dominant mesomorphic somatotype whereas non-athletic college women tended to be endomorphic in structure.

In 1963 Hebbelinck and Postma's study in South Africa on 52 male physical education majors looked for a relationship between motor performance tests, somatotyping and anthropometric measurements. Using anthropometry, they found a very insignificant relationship between body measurements and motor performance tests with one exception - a significant correlation between large neck girth and the shot put. The most predominant somatotype within this select group was that of the meso-

morph. The ecto-mesomorph held superior motor performance scores in all activities tested except the shot put.

In 1943, DiGiovanna correlated anthropometric measurements such as sitting height, standing height, weight and arm span with arm-pulling force and total strength to determine their significance to success in college athletics. From his results, DiGiovanna inferred that "different sports tend to favor individuals who are uniquely patterned structurally and functionally. Specifically, baseball players were shorter, had greater arm girth, arm pull, total strength and power. Basketball men had greater explosive power, were taller, heavier, had greater sitting height, leg length, shoulder breadth, chest depth, arm span and greater strength of the legs and arm pull. Gymnasts were shorter, had greater explosive power, shorter legs, and narrower hips. They were also unique in having greater arm girths, stronger grips, higher arm strength and above average scores on total force." (Morris and Underwood, pg. 101)

An increasing number of researchers (8, 13, 23, 27, 38, 47) have reported that physique plays a major role in determining track and field events in which a female athlete would excel. Cureton and Hirata reported that people with relatively short, small trunks and arms and legs were good jumpers, runners, vaulters and hurdlers. People with a short, heavy stature were proficient at such sports as weight lifting, weight throwing, wrestling and gymnastics. Hirata and Malina et. al. further subdivided athletes, reported as summarized by Plowman that the physique of a runner varies in linearity with the distance of the run. Sprinters, short legged but intermediate in height, are muscular in arms and legs. Strength for rapid acceleration is essential here. As the distance of

the run increases, endurance rather than strength becomes more essential to the runner. Thus, long distance runners are typically small, but long legged and slightly muscular with narrow shoulders and hips. Jumpers and hurdlers tend to be intermediate in height (long legs) and lean (ectomorphys) with larger calf circumference than sprinters (38) - lower body strength is essential. The opposite holds true for throwers. Since the strength of the whole body is necessary for these events, a thrower is tall, heavy with wide shoulders and hips, large muscles and more body fat than other athletes (38).

In Hay and Watson's somatotyping of the female athlete in the 1969 New Zealand Amateur Athletic Association Track and Field Championships, New Zealand women athletes were on the whole significantly more mesomorphic, a little more ectomorphic and a little less endomorphic than average New Zealand women of the same age. Specifically, they found throwers were more endomorphic than middle and long distance runners and less ectomorphic than middle distance runners and jumpers.

R. C. Nelson and Carter reported the female gymnast to be the shortest, lightest and most mesomorphic of female athletes (8, 41, 47). Likewise, Hirata (27), measuring 1964 Olympic athletes in Tokyo, reported similar characteristics in male gymnasts. Gymnasts had shorter tibias, feet, forearms, and smaller total arm lengths and leg circumferences. However, they had large chests when compared to their height and were short relative to their body weight.

Carter (10) reported that all channel swimmers, due to the fact that they must carry more fat for environmental adaptation, were endomesomorphic or meso-endomorphic whereas the competitive swimmers on the San Diego Swim Team and the Olympics were largely endo-mesomorphic with

some ecto-mesomorphic and meso-ectomorphic tendencies. Thus, channel swimmers were shorter and heavier than the competitive swimmers. Cureton also reported similar findings (13).

According to Sinning, Cunningham, Racaniello and Sholes (53), female Nordic skiers were predominantly mesomorphic and low in endomorphy and ectomorphy. They were taller and weighed less than the average athlete. In this study, only track athletes, gymnasts and swimmers had less fat. Nordic skiers' somatotype fell between athletes whose skills involved speed and power (sprinters) and athletes with skills involving endurance (long distance runners). The only readily apparent similarities between Olympic athletes and Nordic skiers was the dominance of mesomorphy. In the study by Ross and Day (49) in 1972, alpine skiers were ecto-mesomorphic but the girls in this study were young and had not yet developed their secondary sex characteristics of higher fat content as compared to the mature Nordic skiers.

A number of studies have been done on female basketball players (8, 37, 51). In A. S. Lewis's article on physique of New Zealand male, grade A basketball players, mesomorphy was dominant with low but equal components of endomorphy and ectomorphy, i.e. Sheldon's somatotpye of 3-5-3. He found that short players with a larger than average mesomorphic component were successful as they overcame their lack of height. A wide range in height and weight existed among the players in this study.

It was reported by Heath in Carter's review (8) that USSR female basketball players were 'fairly' tall and heavy for women. There was a low ectomorphy and a close balance between endomorphy and mesomorphy.

In a study done at the 1974 Canadian Women's Intercollegiate Athletic Union Basketball Championships, Alexander (1) reported no cor-

relation between basketball performance and somatotype components. However, in terms of anthropometric measurements, she found that top female basketball players weighed more, had larger biceps, calves and humerus diameters than the normal female population. She noted generally female basketball players were heavier and taller than the female norm. In Beall's article as reported by Alexander (1), basketball players had long arms and feet and great shoulder breadth. Plowman's (47) review described basketball players as fairly tall, heavy endo-mesomorphic with some players in ectomorphy.

In Morris and Underwood's (40) article, "The Woman Athlete: Structurally Speaking," the athletic woman was more mesomorphic, less ectomorphic and slightly less endomorphic than the average college woman. This does not completely coincide with Hay and Watson's study previously cited. Meso-endomorphic was the predominant body physique of the female athlete (softball, field hockey, baseball and tennis players, gymnasts, and divers) with some endo-mesomorphic in gymnastics, diving and tennis. Basketball players were tallest and had the longest limbs, trunks and shoulder width of all athletes measured and gymnasts were the shortest as cited earlier. Field hockey fullbacks and goalies were second tallest and had average trunk lengths. Field hockey fullbacks and goalies also weighed the heaviest, while basketball players were second and gymnasts were the lightest. Hockey fullbacks and track women had small feet and large hands, whereas hockey forwards, tennis players and golfers had large feet and small hands. Field hockey fullbacks and goalies had the longest foreleg measurement but only average forearm length. Divers had the shortest legs. Even gymnasts had longer arms and legs and broader shoulders than the divers. Tennis players had long forearms but short

upper arms; in addition, they had broad hips and narrow shoulders. The Crural Index was found not to be significant in other sports, contrary to Cureton and Thorsen, but in field hockey fullbacks and goalies, gymnasts and divers, it was found to be high. The ratio of shoulder width to hip width was high in gymnasts but low in field hockey fullbacks and goalies, golfers and softball players. It was low in games where hitting for distance was important. The ratio of leg length to trunk length was high in track women and gymnasts.

In R. E. Johnston and J. M. Watson's study (33) in 1968, it was found that women with an above average muscularity (mesomorph) excelled in both basketball and field hockey with field hockey members having the larger mesomorphic component. As well, mesomorphy was found to be higher in the attacker (forward) than in the defender (defense). This may be related to Sheldon's (50, 51) work on temperament of a mesomorph; assertive, energetic, aggressive with a love and need for physical exercise. As well, Carruth's (7) work indicated a significant relationship between mesomorphy and power, strength, speed, flexibility, balance and body coordination. The defense in both sports were taller and heavier than the attackers. Generally the basketball players were taller (ectomorphic) and weighed more than the field hockey players. However, the increased height was more significant than their increased weight and thus basketball players were more ectomorphic in nature. In field hockey, weight is required in good tackling and clearing whereas the basketball player depends on jumping and height. Thus mesomorphy was higher overall in field hockey players than in basketball players. The shortest players in both sports were one unit higher in mesomorphy than the tallest players. The increased muscle and bone of the shorter player appeared to compensate for their

shorter height. It was also found that endomorphy in all players of both sports was constant which indicated that women with average adipose tissue could participate successfully in either sport. Ectomorphy alone differentiated field hockey and basketball players with the latter being taller.

CHAPTER III

METHODS AND PROCEDURES

SAMPLE

The anthropometric measurements were taken on 55 junior and 51 senior women's provincial field hockey players. The junior provincial players from British Columbia, Alberta, Manitoba and Ontario were measured in Winnipeg on August 1st through 4th during the 1975 Canadian Junior Women's National Field Hockey Tournament. The juniors ranged in age from 16 to 19 years with a mean of 17.73 years.

The senior provincial players from British Columbia, Saskatchewan, Alberta and Manitoba were measured in Regina on August 9th through 13th during the 1975 Western Canada Summer Games. Their age range was much greater stemming from 17 to 33 years with a mean of 22.57 years.

The four western provinces were chosen because of accessibility. Due to the fact that Saskatchewan did not have a junior women's provincial field hockey team the Ontario team was substituted.

The number of players tested per position are shown in Table I.

TABLE I

DESCRIPTION OF SUBJECTS
BY AGE AND POSITION

POSITIONS	SENIORS	JUNIORS
FORWARDS	21	28
HALFBACKS	18	15
FULLBACKS	7	9
GOALIES	5	3
Total	51	55

N = 106

TESTING SITE

During the Canadian Junior Women's National Field Hockey Tournament

measurements of all participants took place at the hotel in which all the field hockey players were residing. To establish consistency in recording measurements, all the measuring apparatus necessary to complete the pertinent calculations were set up within one location for the entire duration of the tournament.

At the Western Canada Games, the measuring devices were housed in a room at the University of Saskatchewan, Regina campus, on the actual site of the field hockey meet. The equipment was again established and calibrated for the total period of tournament time that field hockey was being played during the games.

PRELIMINARIES

Prior to any measuring, all junior and senior players were asked to complete a form defining name, age, provincial team, level of competition (sr./jr.), total years playing field hockey, years on provincial team as senior and/or junior, present playing position, years at present position, other position(s) played, and years at other positions (Appendix A).

MEASURING APPARATUS

All measurements were calibrated in the metric system. The anthropometric measurements consisted of 28 individual variables and ten comparative indices. The individual variables were categorized into heights, lengths, girths and breadths, circumferences, skinfolds, and weight.

Height measurements (standing height and sitting height) as well as arm span measurements were taken with the Lufkin W6110 metal tape.

Length measurements (thigh length, foreleg length, arm length, upper arm length and forearm length) with the exception of the foot length and hand length, were taken with a cloth measuring tape.

Girth and breadth measurements (ankle girth, knee girth, wrist girth, bi-

cristal breadth, biacromial breadth, bideltoid breadth and bitrochanteric breadth) were taken with wooden breadth calipers.

Circumferences (knee circumference, ankle circumference, wrist circumference, biceps circumference, thigh circumference) were taken with the Lufkin MD metal tape.

Hand length and hand span were measured on a specially designed measuring board (Figure 4).

Skinfolds were taken with the Lange Skinfold Calipers.

Weight was taken on the Health O Meter Scale.

ANTHROPOMETRIC MEASURING TECHNIQUES

All anthropometric measurements were taken with the subject dressed in bra and panties.

Standing Height: The subject stood in the anatomical position in front of the tape measure with her os calcaneus and occiput against the wall. A board was placed on her head at a ninety degree angle to the wall and a reading was taken (Figures 1 and 2). The measurement was taken with limits of accuracy of .5 cm.

Sitting Height: The subject sat on a bench placed in front of the tape measure with thighs together and parallel to the floor. Feet were placed flat on the floor and the back and occiput were against the wall. The subject's arms rested comfortably in front of her body. A board was placed on each subject's head at a ninety degree angle to the wall and a reading was taken. The actual sitting height was taken from the subject's ischial tuberosities to the apex of the cranium (Figure 2). The measurement was taken with limits of accuracy of .5 cm.

Thigh Length: The subject stood in the anatomical position. The greater trochanter on the femur and the lateral femoral condyle were palpated and

FIGURE 1

LATERAL ASPECT OF CRANIUM

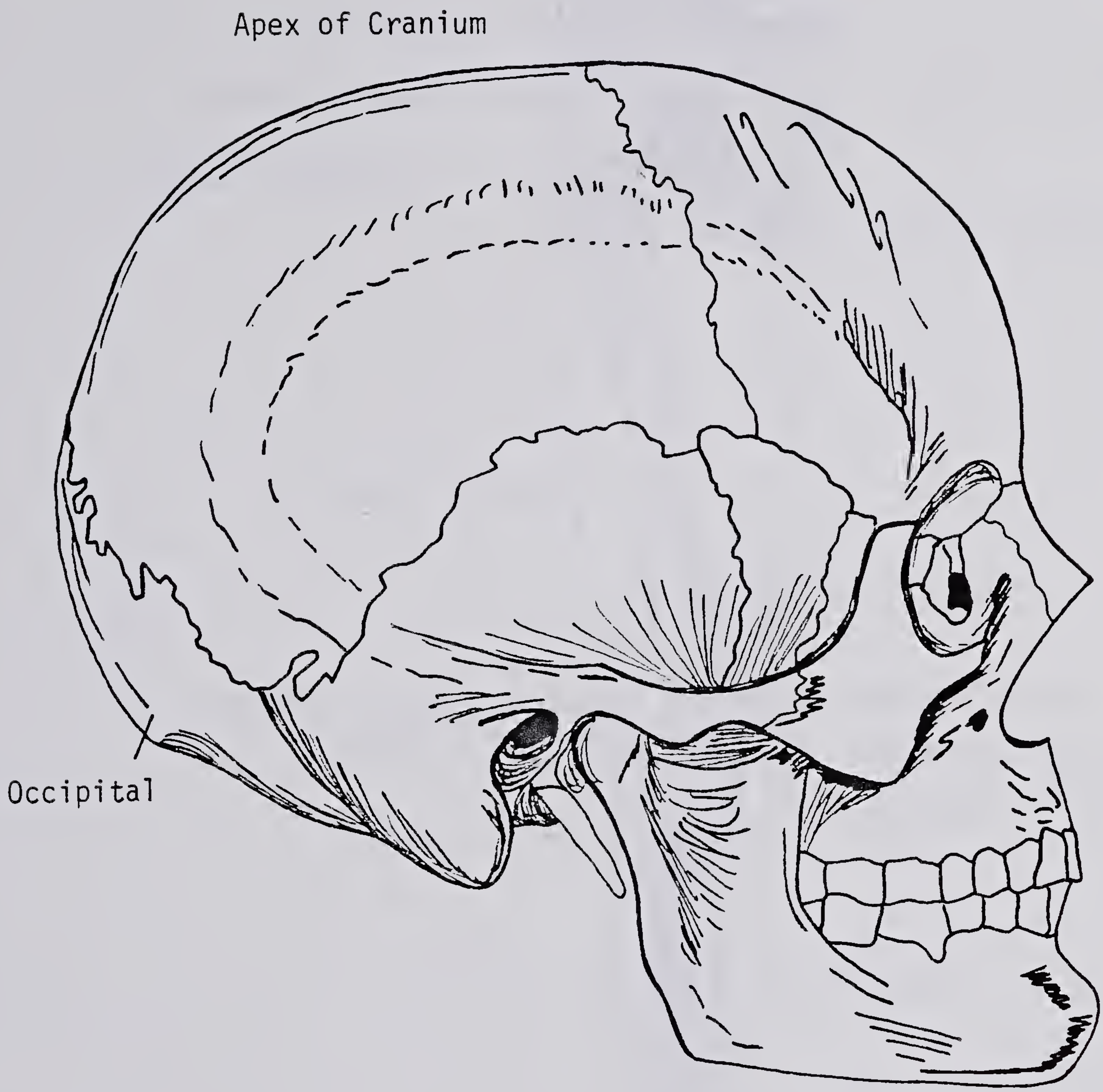
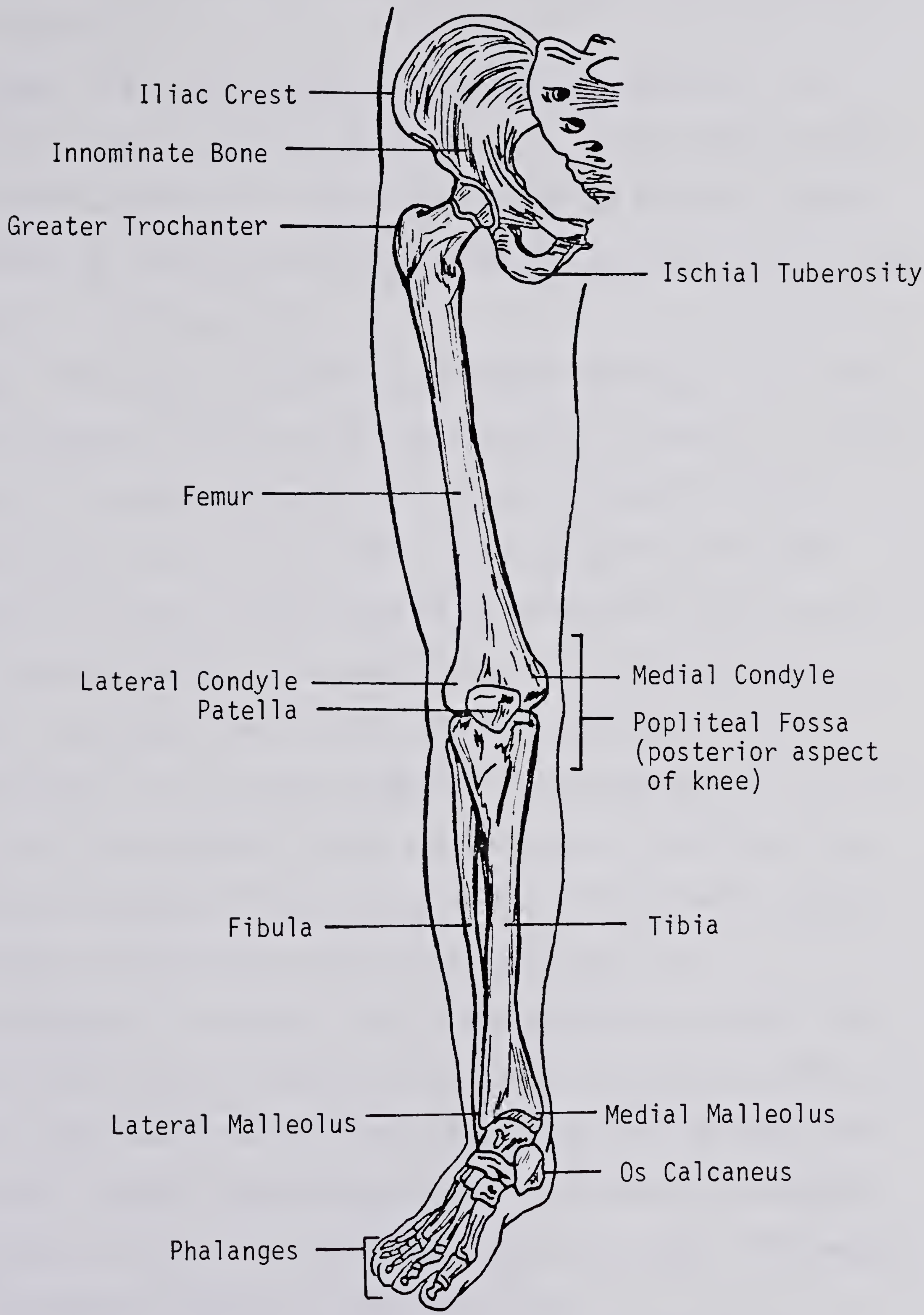


FIGURE 2

ANTERIOR ASPECT OF LOWER LIMB



inscribed with an X. The distance from the X on the greater trochanter to the X on the lateral femoral condyle was taken with limits of accuracy of .5 cm (Figure 2).

Foreleg Length: The subject stood in the anatomical position. The lateral femoral condyle and the lateral malleolus of the fibula were palpated and inscribed with an X. The distance from the X on the lateral femoral condyle to the X on the lateral malleolus was measured with limits of accuracy of .5 cm (Figure 2).

Foot Length: The subject stood in the anatomical position. The breadth caliper was placed on the floor with the stationary bar posterior to the os calcaneus. The measuring base of the breadth caliper was placed against the lateral aspect of the foot. The adjustable bar was then moved so that it would be resting against the distal end of the longest toe. All measurements were taken with limits of accuracy of .1 cm.

Knee Girth: The subject stood in the anatomical position. The medial and lateral femoral condyles were palpated and inscribed with an X. The stationary bar of the breadth caliper was located over the lateral condyle while the adjustable bar was placed on the X of the medial condyle. The measurement was taken with limits of accuracy of .1 cm.

Knee Circumference: The subject stood in the anatomical position. The medial and lateral femoral condyles were palpated and inscribed with an X. The flexible metal tape encircled the knee over the X on the medial and lateral femoral condyles including the anterior surface of the patella and the posterior surface of the popliteal fossa (Figure 2). All measurements were taken with limits of accuracy of .1 cm.

Ankle Girth: The subject stood in the anatomical position. The medial and lateral malleolus of the tibia and fibula respectively were palpated

and inscribed with an X. The stationary bar of the breadth caliper was placed on the X of the medial malleolus while the adjustable bar was placed over the X of the lateral malleolus (Figure 2). The measurement was taken with limits of accuracy of .1 cm.

Ankle Circumference: The subject stood in the anatomical position. The medial and lateral malleolus of the tibia and fibula respectively were palpated and inscribed with an X. The flexible metal tape encircled the ankle over the X on the medial and lateral malleoli including the anterior and posterior aspect of the ankle. The measurement was taken with limits of accuracy of .5 cm.

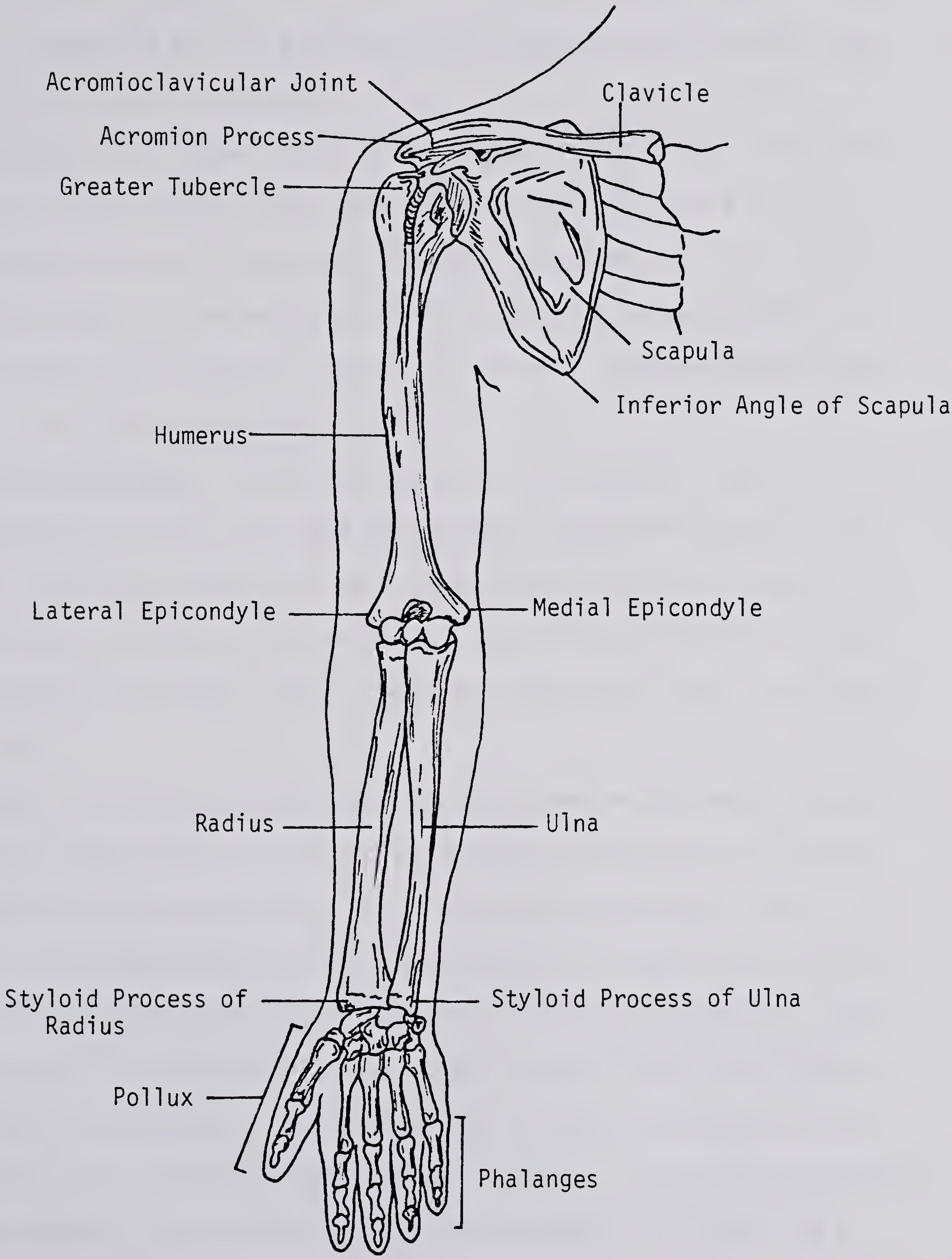
Arm Span: The subject stood in the anatomical position with her back to the tape measure and her os calcaneus and occiput against the wall. Her upper extremities were stretched out in an anatomical position at shoulder height along the tape that was stretched parallel to the floor. A board was placed at the distal end of the outstretched extremity at a ninety-degree angle to the floor and the tape. A reading was taken with limits of accuracy of .5 cm.

Arm Length: The subject stood in the anatomical position. The greater tubercle of the left humerus was palpated and inscribed with an X as was the styloid process of the ulna. The distance from the X on the greater tubercle of the humerus to the X on the styloid process of the ulna was measured with limits of accuracy of .5 cm (Figure 3).

Upper Arm Length: The subject stood in the anatomical position. The styloid process of the ulna and radius were palpated and inscribed with an X. The distance between the X on the greater tubercle and the X on the medial epicondyle was measured with limits of accuracy of .5 cm (Figure 3).

FIGURE 3

ANTERIOR ASPECT OF UPPER LIMB



Forearm Length: The subject stood in the anatomical position. The medial epicondyle of the humerus was palpated and inscribed with an X as was the styloid process of the ulna. The distance between the X on the medial epicondyle and the X on the styloid process of the ulna was measured with limits of accuracy of .5 cm.

Wrist Girth: The subject stood in the anatomical position. The styloid process of the ulna and radius were palpated and inscribed with an X. The stationary bar of the breadth calipers was placed over the X of the styloid process of the radius while the adjustable bar was placed over the X of the ulnar styloid process. All wrist girth measurements were taken with limits of accuracy of .1 cm.

Wrist Circumference: The subject stood in the anatomical position. The styloid process of the ulna and radius were palpated and inscribed with an X. The flexible metal tape was placed around the wrist so that it covered the X of the styloid process of the ulna as well as the radius. The tape was pulled taut and a reading was taken with limits of accuracy of .5 cm.

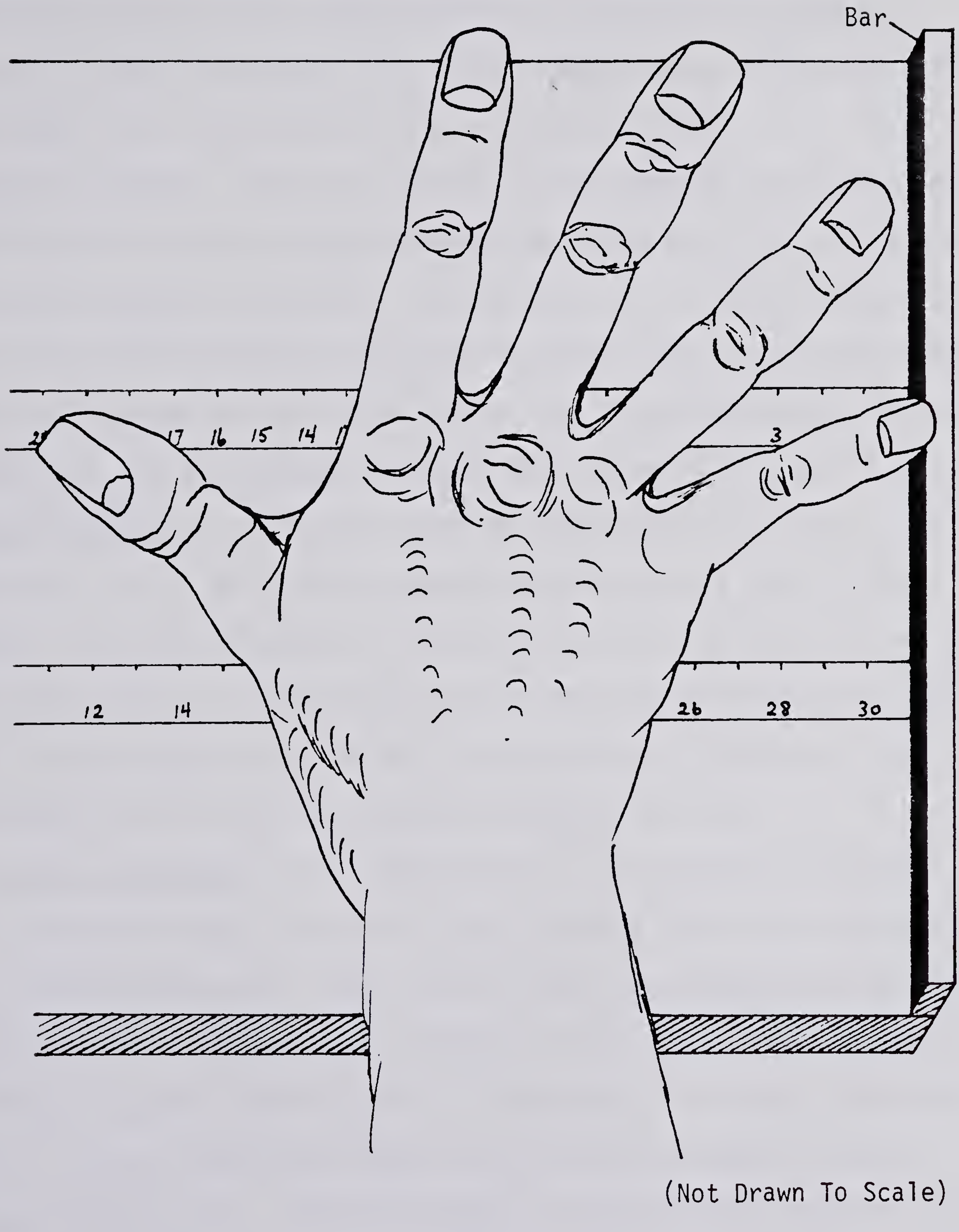
Hand Span: The subject placed her hand palm down on the measuring board with the distal portion of the little phalange resting against the bar. The phalanges were extended as far as possible on the upper scale of the board and a measurement taken at the distal end of the pollux (Figure 4). All hand span measurements were taken with limits of accuracy of .1 cm.

Hand Length: The styloid process of the ulna and radius were palpated and inscribed with an X. The subject laid her hand, palm down on the measuring board, with phalanges flat and together. The styloid processes of the ulna and radius were in line with the edge of the board and a measurement was taken at the distal end of the middle phalanx. The

FIGURE 4

HAND SPAN MEASUREMENT

Measuring Board With Scale



(Not Drawn To Scale)

measurement was taken with limits of accuracy of .5 cm.

Bicristal Breadth: The subject stood in the anatomical position. The iliac crest of both innominate bones were palpated. The stationary bar of the breadth caliper was placed over the iliac crest of the right innominate bone while the adjustable bar of the breadth caliper was placed over the iliac crest of the left innominate bone (Figure 2). The measurement was taken with limits of accuracy of .5 cm.

Biacromial Breadth: The subject stood in the anatomical position. Each acromioclavicular joint was palpated and marked with a line running along its antero-posterior junction. The stationary bar of the breadth caliper was placed along the line on the right acromioclavicular joint while the adjustable bar was placed on the line on the left acromioclavicular joint (Figure 3). The measurement was taken with limits of accuracy of .5 cm.

Bideltoid Breadth: The subject stood in the anatomical position. The stationary bar of the breadth caliper was placed over a point halfway between the distal attachment of the deltoid and the acromion process of the right scapula. The adjustable bar of the breadth caliper was placed over the same location on the left arm and held taut (Figure 3). All measurements were taken with limits of accuracy of .5 cm.

Bitrochanteric Breadth: The subject stood in the anatomical position. The greater trochanter on both the right and left femurs were palpated and inscribed with an X. The stationary bar of the breadth caliper was placed on the X of the greater trochanter on the right femur while the adjustable bar was placed on the X of the greater trochanter on the left femur. The measurement was taken with limits of accuracy of .5 cm.

Biceps Circumference: The subject stood in the anatomical position. The greater tubercle and the lateral epicondyle of the humerus were palpated

and inscribed with an X. The biceps circumference was taken with the flexible metal tape at a point halfway between the X on the greater tubercle and the X on the lateral epicondyle (Figure 3). The tape was tight enough so as not to cause an indentation along the skin surface. The measurement was taken with limits of accuracy of .5 cm.

Thigh Circumference: The subject sat on the edge of a bench with her feet flat on the floor. Her thighs were parallel to the floor. The greater trochanter and the lateral condyle of the femur were palpated and inscribed with an X. At a point halfway between the X on the greater trochanter and the X on the lateral condyle of the femur, the thigh circumference was taken with the flexible metal tape. The tape measure was tight enough so as not to make an indentation along the skin surface. The measurement was taken with limits of accuracy of .5 cm.

Weight: The subject stood in her bra and panties in the anatomical position on the scale. The reading was taken in kilograms with limits of accuracy of .5 kilograms.

Skinfolds: The skin was grasped between the thumb and forefinger of the left hand and gently lifted away from the body about 2.5 centimeters in depth. The tissue grasped consisted of two layers of skin and subcutaneous fat. No muscle or fascia was involved in the measurement. The skinfold calipers were placed about a centimeter in from the end of the thumb and index finger. A reading was taken in millimeters and the skin was gently released. Limit of accuracy was 1 millimeter.

(a) triceps: The triceps skinfold measurement was taken on the posterior aspect of the arm midway between the acromion process of the scapula and the olecranon process of the ulna. The arm was relaxed at the side of the trunk.

(b) suprailiac: The suprailiac skinfold measurement was taken at a forty-five degree angle supero-medial to the iliac crest.

(c) subscapular: The subscapular skinfold measurement was taken approximately 2.5 centimeters below the inferior angle of the scapula. The skin was grasped at a forty-five degree angle toward the midline of the body.

Percent Body Fat: In order to obtain the body fat expressed as a percentage of weight, the body density had to be calculated from the triceps and suprailiac skinfold measurements. The body density was then put into Brozek's formula(s) to find the percent body fat.

COMPARATIVE INDICES

The following comparative indices were calculated: Inverse ponderal index (height/$\sqrt[3]{\text{weight}}$), standing height to percent body weight, cormic index (sitting height/standing height), brachial index (forearm length/upper arm length), relative arm length (total arm length/standing height), upper limb length to lower limb length (total arm length/trochanteric height), forearm length to tibial length, crural index (tibial length/femur length), biacromial breadth to bicristal breadth, trunk length to leg length (sitting height/trochanteric height).

SOMATOSCOPY

The individuals were subjectively categorized by inspection as being endomorphic, mesomorphic and ectomorphic in nature by employing the checklist of morphological characteristics for each somatotype as outlined by Cureton (Appendix B).

STATISTICAL ANALYSIS

Two-way analysis of variance was employed to examine the data as each anthropometric measurement was analysed in its relationship to two

age levels and four field positions in the sport of field hockey.

The computer program, Statistical Package for the Social Sciences, was run at the University of Alberta, Computing Sciences, on the Amdahl 470V7.

CHAPTER IV

RESULTS AND DISCUSSION

CHARACTERISTICS OF SUBJECTS

The means and ranges of the anthropometric measurements and comparative indices of the one hundred and six subjects participating in this study are presented in Table II and III respectively.

TABLE II

ANTHROPOMETRIC MEASUREMENTS OF SUBJECTS

Anthropometric Measurements	Mean	Range
Standing Height (cm)	163.85	149.86-175.26
Sitting Height (cm)	85.47	74.30- 92.08
Thigh Length (cm)	36.99	30.50- 41.50
Foreleg Length (cm)	39.80	34.50- 44.00
Foot Length (cm)	23.85	20.70- 25.80
Knee Girth (cm)	10.28	9.00- 11.70
Knee Circumference (cm)	34.43	30.10- 41.00
Ankle Girth (cm)	6.50	5.30- 7.20
Ankle Circumference (cm)	23.34	21.00- 26.00
Arm Span (cm)	163.52	144.78-179.07
Arm Length (cm)	50.58	46.00- 56.00
Upper Arm Length (cm)	28.46	24.50- 31.50
Forearm Length (cm)	22.39	21.00- 27.50
Wrist Girth (cm)	5.10	4.30- 5.80
Wrist Circumference (cm)	14.61	13.00- 16.50
Hand Length (cm)	18.88	16.00- 23.00
Hand Span (cm)	19.83	16.00- 22.00
Bicristal Breadth (cm)	25.64	21.00- 29.90
Biacromial Breadth (cm)	32.03	27.90- 39.50
Bideltoid Breadth (cm)	39.94	35.40- 45.00
Bitrochanteric Breadth (cm)	32.89	28.70- 37.00
Biceps Circumference (cm)	24.21	20.00- 31.50
Thigh Circumference (cm)	49.32	42.50- 59.50
Weight (kilograms)	58.46	46.00- 80.90
Skinfold: Triceps (mm)	14.38	7.00- 21.00
Suprailiac (mm)	11.97	5.00- 19.00
Subscapular (mm)	10.97	6.00- 19.00
Percent Body Fat	19.43	15.14- 25.52

TABLE III

COMPARATIVE INDICES OF SUBJECTS

Comparative Indices	Mean	Range
Inverse Ponderal Index	12.79	11.59-13.71
Standing Height/Percent Body Weight	8.52	6.49-10.94
Cormic Index	.52	.48- .57
Brachial Index	.88	.75- 1.00
Relative Arm Length	.31	.29- .34
Upper Limb Length/Lower Limb Length	.68	.61- .73
Forearm Length/Tibial Length	.68	.57- .77
Crural Index	.99	.87- 1.17
Biacromial Breadth/Bicristal Breadth	1.26	1.04- 1.65
Trunk Length/Leg Length	1.12	.98- 1.31

The mean anthropometric measurements and comparative indices in this study were comparable with results from previous studies performed by such investigators as Garrity (20), Medved (39), Oyster and Wooten (42) and Sinning, Cunningham, Racaniello and Sholes (53). Norms such as arm span, hand length, hand span, relative arm length, and forearm length to tibial length were not available for comparison.

DIFFERENCES IN ANTHROPOMETRIC DATA BETWEEN JUNIOR AND SENIOR LEVEL FIELD HOCKEY PLAYERS

The junior team ranged in age from 16 to 19 years with a mean of 17.73. The values for the senior team were 17 to 33 years and 22.57 respectively. Anthropometric measurements taken in this study yielded a significant difference between junior and senior level players on knee circumference and bicristal breadth. Each of these was significant at the .05 level with the probability of the former being .046 and the later being .017 (Table IV) (Appendix C). Due to the fact that growth stature changes with age, the anthropometric differences above can be attributed at least in part to difference in age. Research concerning the anthropometric age relationship is definitely lacking.

TABLE IV: MEANS OF ANTHROPOMETRIC MEASUREMENTS FOR POSITIONS (N=106)

ANTHROPOMETRIC MEASUREMENTS	SENIOR (N=51)	JUNIOR (N=55)	GOAL (N=8)	FULLBACK (N=16)	HALFBACK (N=33)	FORWARD (N=49)
STANDING HEIGHT (cm)	164.92	162.77	163.75	162.66	163.36	164.54
SITTING HEIGHT (cm)	86.05	84.88	86.25	85.94	85.03	85.42
THIGH LENGTH (cm)	37.31	36.66	38.56	36.61	36.53	37.14
FORELEG LENGTH (cm)	39.83	39.76	39.43	39.63	39.63	40.02
FOOT LENGTH (cm)	23.87	23.84	23.78	23.98	23.87	23.81
KNEE GIRTH (cm)	10.32	10.25	10.32	10.56	10.31	10.17
KNEE CIRCUMFERENCE (cm)	34.76*	34.11*	34.56	35.10	34.41	34.17
ANKLE GIRTH (cm)	6.53	6.47	6.46	6.69	6.48	6.44
ANKLE CIRCUMFERENCE (cm)	23.29	23.38	23.18	23.55	23.27	23.33
ARM SPAN (cm)	164.48	162.57	162.62	163.61	162.80	164.04
ARM LENGTH (cm)	50.91	51.25	50.62	51.16	50.91	51.24
UPPER ARM LENGTH (cm)	28.03	28.89	27.62	28.50	28.16	28.79
FOREARM LENGTH (cm)	24.44	20.34	24.00	24.25	24.33	24.22
WRIST GIRTH (cm)	5.09	5.11	5.06	5.06	5.14	5.10
WRIST CIRCUMFERENCE (cm)	14.57	14.65	14.56	14.66	14.65	14.58
HAND LENGTH (cm)	18.89	18.87	19.06	18.69	18.63	19.07

HAND SPAN (cm)	19.78	19.87	20.12	19.91	19.64	19.87
BICRISTAL BREADTH (cm)	26.03*	25.25*	26.37	26.33	25.65	25.26
BIACROMIAL BREADTH (cm)	32.17	31.89	31.12	32.15	32.22	32.01
BIDELTOID BREADTH (cm)	39.61	40.26	39.25	40.58	39.93	39.84
BITROCHANTERIC BREADTH (cm)	33.22	32.56	33.18	33.47	33.00	32.56
BICEPS CIRCUMFERENCE (cm)	24.31	24.12	24.25	25.11	24.13	23.94
THIGH CIRCUMFERENCE (cm)	49.75	48.88	49.87	50.86	49.18	48.74
WEIGHT (kilograms)	58.87	58.05	58.50	60.52	57.95	58.01
SKINFOLD: TRICEPS (mm)	14.51	14.24	14.50	15.77	13.96	14.10
SUPRAILIAC (mm)	11.76	12.18	13.87	12.88	11.76	11.48
SUBSCAPULAR (mm)	11.00	10.94	11.37	11.72	10.60	10.86
PONDERAL INDEX	12.79	12.76	12.86	12.53	12.84	12.86
STANDING HEIGHT/% BODY WGT.	282.76	282.58	281.52	272.12	283.28	286.29
CORMIC INDEX	0.52	0.52	0.52	0.52	0.52	0.51
BRACHIAL INDEX	0.87	2.33	0.87	0.85	0.86	2.46
RELATIVE ARM LENGTH	0.30	0.31	0.30	0.31	0.31	0.31
FOREARM/TIBIA	0.61	1.69	0.60	0.61	0.61	1.78
CRURAL INDEX	1.07	1.08	1.02	1.08	1.08	1.08
BIACROMIAL/BIDELTOID	1.24	1.27	1.19	1.22	1.26	1.27
TRUNK LENGTH/LEG LENGTH	1.11	1.11	1.10	1.22	1.26	1.27

TABLE IV: CONTINUED

ANTHROPOMETRIC MEASUREMENTS	SENIOR	JUNIOR	GOAL	FULLBACK	HALFBACK	FORWARD
DENSITY	1.05	1.05	1.05	1.05	1.05	1.05
PERCENT BODY FAT	19.96	19.38	19.85	20.59	19.05	19.21

(*Difference significant at .05 level)

DIFFERENCES IN ANTHROPOMETRIC DATA FOR POSITIONS IN FIELD HOCKEY

There were no significant differences among the various positions in field hockey with respect to the anthropometric measurements viewed.

It can be observed from Table IV that the forwards were the tallest with the longest arm span measurements. Goalies and fullbacks were heavier with larger bitrochanteric breadth, bicristal breadth, biceps circumference and thigh circumference than forwards and halfbacks. Goalies also had small arm spans but large hand span measurements.

Morris and Underwood (40) observed fullbacks to have small feet and large hands when compared to forwards who had large feet and small hands. This was not observed in Table IV; fullbacks had large feet with small hand length but large hand span. Forwards had average feet but large hand length and small hand span. Both studies were in agreement with goalies and fullbacks being heavier than halfbacks and forwards as stated above.

In Johnston and Watson's study (33), the forwards were shorter and lighter than the defense. However, here the forwards were taller and lighter with the defense being the shortest and heaviest.

There was a significant A-B interaction for triceps skinfold and for crural index (Table V) at the .05 level. The probability level for these two interactions was .49 and .05 respectively. Should this study be repeated, there would be a borderline chance that these results would not occur again. No clear-cut explanation can be given for these results. Also no comparative studies have been done in this area to the knowledge of the investigator.

TABLE V: MEANS OF ANTHROPOMETRIC MEASUREMENTS FOR JUNIORS AND SENIORS PER POSITION (N = 106)

ANTHROPOMETRIC MEASUREMENTS	GOAL		FULLBACKS		HALFBACKS		FORWARD	
	Senior	Junior	Senior	Junior	Senior	Junior	Senior	Junior
STANDING HEIGHT (cm)	164.40	162.66	164.25	161.40	165.40	161.33	164.95	164.15
SITTING HEIGHT (cm)	86.80	85.33	87.25	84.90	85.73	84.33	85.70	85.15
THIGH LENGTH (cm)	39.40	37.16	36.12	37.00	36.83	36.23	37.58	36.73
FORELEG LENGTH (cm)	39.10	40.00	39.62	39.65	40.36	38.90	39.72	40.28
FOOT LENGTH (cm)	23.56	24.16	24.03	23.94	23.92	23.83	23.85	23.78
KNEE GIRTH (cm)	10.40	10.20	10.81	10.37	10.23	10.40	10.19	10.15
KNEE CIRCUM-FERENCE (cm)	34.90	34.00	36.43	34.03	34.50	34.33	34.33	34.02
ANKLE GIRTH (cm)	6.46	6.46	6.93	6.50	6.47	6.49	6.44	6.44
ANKLE CIRCUM-FERENCE (cm)	22.90	23.66	23.50	23.60	23.22	23.32	23.35	23.31
ARM SPAN (cm)	161.80	164.00	163.75	163.50	165.80	159.80	164.45	163.65
ARM LENGTH (cm)	50.80	50.33	50.25	51.90	51.43	50.40	50.83	51.61
UPPER ARM LENGTH (cm)	28.10	26.83	28.18	28.75	28.23	28.10	27.85	29.65

FOREARM LENGTH (cm)	24.10	23.83	24.00	24.45	24.70	23.96	24.50	20.14
WRIST GIRTH (cm)	5.08	5.03	5.12	5.02	5.09	5.19	5.08	5.11
WRIST CIRCUM-FERENCE (cm)	14.80	14.16	14.75	14.60	14.56	14.73	14.47	14.68
HAND LENGTH (cm)	18.80	19.50	18.87	18.55	18.83	18.43	18.95	19.17
HAND SPAN (cm)	20.10	20.16	20.06	19.80	19.76	19.52	19.64	20.07
BICRISTAL BREADTH (cm)	27.50	24.50	27.51	25.40	25.50	25.80	25.56	24.98
BIACROMIAL BREADTH (cm)	30.90	31.50	32.37	31.97	31.93	32.51	32.52	31.55
BIDELTOID BREADTH (cm)	39.20	39.33	40.12	40.95	39.00	40.86	39.91	39.76
BITROCHANTERIC BREADTH (cm)	33.50	32.66	34.37	32.75	33.16	32.83	32.81	32.32
BICEPS CIRCUM-FERENCE (cm)	24.80	23.33	25.56	24.75	23.93	24.33	24.04	23.84
THIGH CIRCUM-FERENCE (cm)	50.00	49.66	51.56	50.30	49.06	49.30	49.52	48.01
WEIGHT (kilogram)	60.20	55.66	62.06	59.30	57.80	58.10	58.20	57.82
SKINFOLDS:								
TRICEPS*	16.40	11.33	15.75	15.80	13.53	14.40	14.33	13.88
SUPRAILIAC	13.60	14.33	13.62	12.30	10.93	12.60	11.29	11.65
SUBSCAPULAR	12.00	10.33	11.50	11.90	10.46	10.73	10.95	10.76

TABLE V: CONTINUED

ANTHROPOMETRIC MEASUREMENTS	GOAL Senior	GOAL Junior	FULLBACKS Senior	FULLBACKS Junior	HALFBACKS Senior	HALFBACKS Junior	FORWARD Senior	FORWARD Junior
PONDERAL INDEX	12.75	12.98	12.56	12.50	12.88	12.81	12.97	12.75
STANDING HEIGHT/ PERCENT BODY WGT.	274.92	292.51	269.56	274.17	287.81	287.74	285.64	286.88
CORMIC INDEX	0.52	0.52	0.53	0.52	0.51	0.52	0.52	0.51
BRACHIAL INDEX	0.85	0.88	0.85	0.85	0.87	0.85	0.88	0.92
RELATIVE ARM LENGTH	0.30	0.30	0.30	0.32	0.31	0.31	0.30	0.31
FOREARM/TIBIA	0.61	0.59	0.60	0.61	0.61	0.61	0.61	0.85
CRURAL INDEX*	0.99	1.07	1.09	1.07	1.10	1.07	1.05	1.10
BIACROMIAL/ BICRISTAL	1.12	1.29	1.18	1.26	1.26	1.27	1.28	1.27
TRUNK LENGTH/ LEG LENGTH	1.10	1.10	1.15	1.10	1.11	1.12	1.11	1.10
DENSITY	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
PERCENT BODY FAT	20.65	19.06	21.18	20.01	19.00	19.10	19.04	19.38

(*Difference significant at .05 level)

SOMATOSCOPY

The subjects' somatoscopy components are presented in Table VI.

TABLE VI

SOMATOSCOPY COMPONENTS

	Seniors					Juniors				
	Forward	Halfback	Fullback	Goalie	TOTAL	Forward	Halfback	Fullback	Goalie	TOTAL
ECTO-MESO	6	5	2	0	13	5	4	2	2	13
ENDO-MESO	6	10	4	4	24	17	4	5	1	28
MESO-ECTO	6	3	1	0	10	5	4	0	0	9
MESO-ENDO	3	0	0	1	4	1	3	2	0	6
TOTALS	21	18	7	5	51	28	15	9	3	55

NOTES 1. One of the senior teams had a reserve goalie.

2. One of the goalies from a junior team refused to be measured.

The majority of field hockey players were mesomorph dominant as their first or second component which was in accordance with somatotypes found in the sports studied by Hay and Watson (23), Hebbelinck and Postma (26), Lewis (37), Morris and Underwood (40), Perbix (46) and Sinning, Cunningham, Racaniello and Sholes (53).

Fourteen of fifty-one senior players and fifteen of fifty-five junior players had mesomorph as their first component while it appeared as a second component in thirty-seven seniors and forty-one juniors (Table VI). Nine senior forwards were either meso-ecto or meso-endo

while six were ecto-meso or endo-meso. Seven junior halfbacks were meso-endo or meso-ecto with four being endo-meso or ecto-meso. Twenty-four senior and twenty-eight junior players were endo-meso with ten of the twenty-four being senior halfbacks and seventeen of the twenty-eight being junior forwards. The juniors and seniors both had thirteen ecto-meso players with the forwards and halfbacks being higher in both age groups.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

The purpose of this study was to show that there were anthropometric measurements characteristic of a specific position in women's field hockey - goalie, fullback, halfback and forward - and that these characteristics were present at a senior as well as junior age category.

The sample consisted of one hundred and six female senior and junior provincial field hockey players from five Canadian provinces. Of these one hundred and six subjects, fifty-five players were from the junior provincial teams while the remaining fifty-one players were from the senior provincial teams.

A total of twenty-eight individual anthropometric measurements were taken on each subject with another ten comparative indices being calculated.

Two way analysis of variance was employed to examine data as each anthropometric measurement was analysed with respect to two age levels and four field positions in the sport of field hockey.

The study concluded that the majority of field hockey players had a high mesomorphic component with varying degrees of ectomorphy and endomorphy.

The relationship between the anthropometric data in junior and senior levels of field hockey was significant at the .05 level for knee circumference and for bicristal breadth.

There were no significant variations among the various positions in field hockey when related to the anthropometric data.

The interaction of age-by-position was significant at the .05 level for triceps skinfold and crural index.

CONCLUSIONS

Within the limitations of the present investigation, the following conclusions appear to be justified:

1. The players were primarily mesomorphic in nature, with varying degrees of ectomorphy and endomorphy, but no extremes.
2. On a team basis, for each of the variables measured, the teams were remarkably similar.
3. No single variable was predictive of women field hockey players.
4. Senior players had greater knee circumference and bicristal breadth.
5. Women with average amounts of adipose tissue could play field hockey. Height was not an essential factor in field hockey.

RECOMMENDATIONS

I recommend that:

1. Further research be done on a larger field hockey population. However, fewer anthropometric measurements should be used.
2. Other parameters such as physical endurance, strength, agility, intelligence, etc. be tested to see if they have any bearing with respect to positions or age.
3. Field hockey players of other countries be tested to see how they would compare with Canadian players.
4. Provincial field hockey players be submerged into an extensive training program for a concentrated period of time in another sport to see if they would also excel in that sport at the provincial level.

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APPENDIX A

DATA SHEET

DATA SHEET

Name ______________________________

Birth Date ______________________________

Provincial Team ______________________________

Sr. _____ Jr. ____

TOTAL Years Playing Field Hockey _________

Years on Provincial Team ________________

Sr. _____ Jr. _____

Present Position ________________________

Years at Present Position ________________

Other Positions Played ___________________

Years at Other Positions ________________

DATA SHEET

Individual Parameters:

1. Standing Height ________________
2. Sitting Height ________________
3. Thigh Length ________________
4. Foreleg Length ________________
5. Foot Length ________________
6. Knee Girth ________________
7. Knee Circumference ________________
8. Ankle Girth ________________
9. Ankle Circumference ________________
10. Arm Span ________________
11. Arm Length (total) ________________
12. Upper Arm Length ________________
13. Forearm Length ________________
14. Wrist Girth ________________
15. Wrist Circumference ________________
16. Hand Length ________________
17. Hand Span ________________
18. Bicristal Breadth ________________
19. Biacromial Breadth ________________
20. Bideltoid Breadth ________________
21. Bitrochanteric Breadth ________________
22. Biceps Circumference ________________
23. Thigh Circumference ________________
24. Weight ________________

25. Skinfold (Triceps) ______________________

26. Skinfold (Iliac Crest) __________________

27. Skinfold (Subscapular) __________________

28. Body Somatotype _________________________

APPENDIX B

SOMATOSCOPY CHARACTERISTICS

SOMATOSCOPY CHARACTERISTICS

Endomorph

I. General Appearance
- large, soft, bulging body
- thick body segments, antero-posterior
- mass concentrated toward center
- roundness and softness of body
- antero-posterior and lateral diameters tend toward equality in the head, neck, trunk and limbs
- hair is fine and sparce

II. Segments

1. Head, Neck, Face
- large, round head
- short, thick neck
- neck forms obtuse angle with chin in lateral plane
- wide, round face; low palate

2. Thoracic Trunk
- broad, thick chest
- wide costal angle
- some fatty breasts
- relatively straight spine
- postural defects of shoulders not common
- clavicular and scapulae hollows well padded

3. Arms, Shoulders, Hands
- short arms, relatively
- short forearms, relatively
- limbs taper from 'hammy' upperarms to

small hands and wrists
- high, square shoulders
- smooth feminine musculature with no sharp muscle contours viz; deltoids and trapezeii
- short fingers, relatively

4. Abdominal Trunk and Pelvis
- large abdomen, full above navel and pendulous
- long abdomen from sternum to pubis
- thick A-P depth at naval
- relatively straight lumbar spine

5. Legs Feet Buttocks
- short legs, relatively
- heavy, fat buttocks with no dimpling or muscle outlines
- heavy 'hammy' thighs
- large, smooth calves
- feet small and weakness common
- foot defects common

<u>Mesomorph</u>

I. General Appearance
- a squareness and hardness of body
- rugged, prominent, massive muscles
- large, prominent bones
- transverse diameters of shoulders, forearms and calves are large, but A-P diameters are less than in endomorphic types

	- central concentration of mass is absent
	- long and upright trunk, proportions variable
	- skin is thick and coarse with conspicuous pores; holds good tan; small wrinkles infrequent
	- hair is coarse, thick or sparse
II. Segments	
1. Head Neck Face	- head variable in size and shape but often cubicle with thick and dense bones - facial bones are prominent, viz: cheek-bones, supra-orbital ridges; square jaws - facial mass great compared to cephalic mass - fairly long, strong neck with great transverse diameter compared to antero-posterior diameter - hair on head variable
2. Thoracic Trunk	- predominates in volume over abdominal volume - wide thorax at apex - little thoracic curve in spine - ribs - strong and heavy
3. Arms Shoulders Hands	- shoulders seem low with trapezium and deltoidious muscles prominent - broad shoulders - clavicles heavy and prominent

	- muscular upperarm, no 'hamming'
	- massive forearms, wrists, hands and fingers
	- upperarm and forearm evenly proportioned
4. Abdominal Trunk and Pelvis	- abdomen is large and heavily muscled; ripples show
	- slender, low waist
	- pelvis sturdy and powerful with borad hips

Ectomorph

I. General Appearance	- thin body segments, antero-posteriorly
	- decentralization of structure
	- linearity, thinness
	- frail, delicate body structure
	- small, thin-diameter bones
	- undernourished appearance
	- small trunk, long limbs
	- profuse hair, baldness uncommon
II. Segments	
1. Head Neck Face	- relatively large cranium
	- bulbous forehead
	- small face, pointed chin, sharp nose
	- long, slender neck
	- poke neck common
	- lips delicate, thin, dry, pale
	- abundant hair on head
2. Thoracic Trunk	- narrow thorax, long compared to abdomen

		- acute costal angle
		- thin chest depth
		- clavicular hollows marked, clavicles prominent
		- winged scapulae, forward shoulders marked
		- ribs prominent
		- kyphoses, marked S-curve
3.	Arms	- long arms, relatively
	Shoulders	- long forearms, compared to upperarm
	Hands	- thin upperarms, muscles not marked
		- shoulder droop and round shoulders marked
		- thin forearms
		- long, thin hands
		- inconspicuous knuckles
4.	Abdominal	- flat abdomen, hollow above navel
	Trunk and	- short abdomen, protrusion common below navel
	Pelvis	- thin, antero-posterior depth at navel
		- lordosis, marked S-curve
5.	Legs	- long legs, relatively
	Feet	- inconspicuous buttocks
	Buttocks	- long forelegs, relatively
		- thin thighs, muscles not marked
		- calves relatively thin
		- feet thin and long

(Checklist published by T.K. Cureton, Jr., "Physical Fitness Appraisal and Guidance," Urbana, Ill.: University of Illinois Press, 86-91, 1947)

APPENDIX C

ANOVAS BY POSITION AND AGE GROUP

ANOVAS BY POSITION AND AGE GROUP

Between Subject Factors Are:

A - Age Group: 1 Junior 2 Senior

B - Position: 1 Goal 2 Fullback 3 Halfback 4 Forward

STANDING HEIGHT (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	92.098	1.	92.098	3.248
B	26.240	3.	8.747	0.308
AB	24.182	3.	8.061	0.284
S-Within	2779.000	98.	28.357	

SITTING HEIGHT (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	34.279	1.	34.279	2.894
B	12.863	3.	4.288	0.362
AB	6.656	3.	2.219	0.187
S-Within	1160.688	98.	11.844	

THIGH LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	8.104	1.	8.104	1.800
B	33.057	3.	11.019	2.448
AB	20.066	3.	6.689	1.486
S-Within	441.125	98.	4.501	

FORELEG LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.000	1.	0.000	0.000
B	2.090	3.	0.697	0.193
AB	13.474	3.	4.491	1.246
S-Within	353.125	98.	3.603	

FOOT LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.129	1.	0.129	0.125
B	0.257	3.	0.086	0.084
AB	1.479	3.	0.493	0.481
S-Within	100.484	98.	1.025	

KNEE GIRTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.275	1.	0.275	0.936
B	1.521	3.	0.507	1.724
AB	0.816	3.	0.272	0.925
S-Within	28.828	98.	0.294	

KNEE CIRCUMFERENCE (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	14.760	1.	14.760	4.096
B	10.355	3.	3.452	0.958
AB	12.959	3.	4.320	1.199
S-Within	353.188	98.	3.604	

ANKLE GIRTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.175	1.	0.175	0.722
B	0.812	3.	0.271	1.118
AB	0.615	3.	0.205	0.846
S-Within	23.734	98.	0.242	

ANKLE CIRCUMFERENCE (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.868	1.	0.868	0.760
B	0.836	3.	0.279	0.244
AB	1.640	3.	0.547	0.479
S-Within	111.930	98.	1.142	

ARM SPAN (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	24.182	1.	24.182	0.549
B	18.008	3.	6.003	0.136
AB	146.636	3.	48.879	1.109
S-Within	4319.000	98.	44.071	

ARM LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.900	1.	0.900	0.175
B	3.923	3.	1.308	0.254
AB	18.104	3.	6.035	1.173
S-Within	504.000	98.	5.143	

UPPER ARM LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.965	1.	0.965	0.128
B	15.114	3.	5.038	0.688
AB	20.323	3.	6.774	0.899
S-Within	738.688	98.	7.538	

FOREARM LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	9299.703	1.	9299.703	0.153
B	28609.113	3.	9536.371	0.157
AB	28334.234	3.	9444.742	0.155
S-Within	5965005.000	98.	60867.395	

WRIST GIRTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.000	1.	0.000	0.003
B	0.071	3.	0.024	0.311
AB	0.101	3.	0.034	0.438
S-Within	7.507	98.	0.077	

WRIST CIRCUMFERENCE (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.167	1.	0.167	0.359
B	0.362	3.	0.121	0.260
AB	1.879	3.	0.626	1.349
S-Within	45.512	98.	0.464	

HAND LENGTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.036	1.	0.036	0.029
B	3.224	3.	1.075	0.873
AB	3.264	3.	1.088	0.884
S-Within	120.605	98.	1.231	

HAND SPAN (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.000	1.	0.000	0.000
B	1.992	3.	0.664	0.491
AB	1.304	3.	0.435	0.321
S-Within	132.566	98.	1.353	

BICRISTAL BREADTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	29.938	1.	29.938	5.880
B	12.573	3.	4.191	0.823
AB	27.237	3.	9.079	1.783
S-Within	498.938	98.	5.091	

BICROMIAL BREADTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.032	1.	0.032	0.008
B	11.287	3.	3.762	0.989
AB	7.396	3.	2.465	0.648
S-Within	372.750	98.	3.804	

BIDELTOID BREADTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	7.396	1.	7.396	2.171
B	13.377	3.	4.459	1.309
AB	9.904	3.	3.301	0.969
S-Within	333.813	98.	3.406	

BITROCHANTERIC BREADTH (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	11.062	1.	11.062	2.189
B	8.200	3.	2.733	0.541
AB	4.084	3.	1.361	0.269
S-Within	495.313	98.	5.054	

BICEPS CIRCUMFERENCE (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	4.406	1.	4.406	1.311
B	15.468	3.	5.156	1.534
AB	7.975	3.	2.658	0.791
S-Within	329.430	98.	3.362	

THIGH CIRCUMFERENCE (cm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	8.425	1.	8.425	0.847
B	43.862	3.	14.621	1.471
AB	8.104	3.	2.701	0.272
S-Within	974.375	98.	9.943	

WEIGHT (kilograms)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	55.985	1.	55.985	1.509
B	91.036	3.	30.345	0.818
AB	60.970	3.	20.323	0.548
S-Within	3635.375	98.	37.096	

TRICEPS SKINFOLD (mm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	21.760	1.	21.760	2.015
B	40.240	3.	13.413	1.242
AB	87.835	3.	29.278	2.711
S-Within	1058.297	98.	10.799	

ILIAC SKINFOLD (mm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	2.124	1.	2.124	0.170
B	65.050	3.	21.683	1.737
AB	19.288	3.	6.429	0.515
S-Within	1223.227	98.	12.482	

SUBSCAPULAR SKINFOLD (mm)

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	1.455	1.	1.455	0.204
B	11.016	3.	3.672	0.514
AB	11.076	3.	3.692	0.517
S-Within	699.813	98.	7.141	

INVERSE PONDERAL INDEX

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.675	1.	0.675	0.373
B	9.551	3.	3.184	1.759
AB	6.399	3.	2.133	1.179
S-Within	177.375	98.	1.810	

STANDING HEIGHT TO PERCENTAGE BODY WEIGHT

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	213.008	1.	213.008	0.336
B	2031.293	3.	677.098	1.069
AB	1494.143	3.	498.047	0.786
S-Within	62064.000	98.	633.306	

CORMIC INDEX = SITTING HEIGHT TO STANDING HEIGHT

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.000	1.	0.000	0.061
B	0.001	3.	0.000	1.270
AB	0.000	3.	0.000	0.307
S-Within	0.025	98.	0.000	

BRACHIAL INDEX = FOREARM LENGTH TO UPPER ARM LENGTH

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	9.568	1.	9.568	0.151
B	29.195	3.	9.732	0.154
AB	28.510	3.	9.503	0.150
S-Within	6199.605	98.	63.261	

RELATIVE ARM LENGTH = TOTAL ARM LENGTH TO STANDING HEIGHT

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.001	1.	0.001	7.050
B	0.000	3.	0.000	0.756
AB	0.001	3.	0.000	2.583
S-Within	0.008	98.	0.000	

TOTAL ARM LENGTH TO TROCHANTERIC HEIGHT

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.001	1.	0.001	7.050
B	0.000	3.	0.000	0.756
AB	0.001	3.	0.000	2.583
S-Within	0.000	98.	0.000	

FOREARM LENGTH TO TIBIAL LENGTH

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	5.143	1.	5.143	0.153
B	15.694	3.	5.231	0.155
AB	15.530	3.	5.177	0.154
S-Within	3298.632	98.	33.660	

CRURAL INDEX = TIBIAL LENGTH TO FEMUR LENGTH

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.006	1.	0.006	1.349
B	0.031	3.	0.010	2.378
AB	0.035	3.	0.012	2.696
S-Within	0.424	98.	0.004	

BIACROMIAL BREADTH TO BICRISTAL BREADTH

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.064	1.	0.064	3.745
B	0.055	3.	0.018	1.076
AB	0.076	3.	0.025	1.473
S-Within	1.679	98.	0.017	

SITTING HEIGHT TO TROCHANTERIC HEIGHT

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.001	1.	0.001	0.380
B	0.006	3.	0.002	0.617
AB	0.008	3.	0.003	0.862
S-Within	0.318	98.	0.003	

DENSITY

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	0.000	1.	0.000	0.382
B	0.000	3.	0.000	1.273
AB	0.000	3.	0.000	1.273
S-Within	0.002	98.	0.000	

PERCENT BODY FAT

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
A	1.801	1.	1.801	0.314
B	17.718	3.	5.906	1.030
AB	15.789	3.	5.263	0.918
S-Within	562.000	98.	5.735	